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ABSTRACT

In recent years both scientists and laypeople have viewed with dismay the notion that science seems mysteriously different from other areas of human concern. Scientific language is part of the mystique. Yet scientific language is human language before it is science. The mystique that people ascribe to scientific language is of their own making, for physical, cognitive, and emotional phenomena are not so different that language cannot serve them all in similar fashion. Laypeople who must make decisions affected by scientific research--and that is everyone--may take heart: they can deal with scientific language with the same benign skepticism and keen analysis that they apply to the language of other disciplines. Recognizing the shared features and fundamental linguistic characteristics that scientific language shares with other language--historians' language, psychologists' language, black English, phatic language--could be the means of establishing mutual confidence between scientists and humanists. Once students have been effectively disabused of the notion that scientific language is "different," teachers and students can approach rational use of the information transmitted by the scientists in textbooks, newspapers, and scientific journals. (RL)

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SCIENTIFIC LANGUAGE:

WHEREIN ITS MYSTIQUE?

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SCIENTIFIC LANGUAGE: WHEREIN ITS MYSTIQUE?

> The power of science for good or evil has troubled other minds than ours. We are not here fumbling with a new dilemma; our subject and our fears are as old as the tool-making civilization.[1]

Thus Jacob Bronowski, in Science and Human Values, suggests the historical antecedents of today's apprehensive, even alarmed view of science. In recent years both scientists and laymen writing in journals as diverse as Science and Saturday Review have viewed with dismay the notion that science seems mysteriously different from other areas of human concern. Herman Bondi of the University of London expresses both the awe and distrust with which laymen often perceive science:

> Although science is very much in the foreground nowadays, with the newspapers talking about it at great length, there still seems to be a fairly widespread lack of understanding of just what science is and how it progresses. The public image of the scientist tends to be that of a magician, occasionally benevolent, though more often giving rise to disastrous inventions, or perhaps that of a man shutting himself into a laboratory and, in his lonely way, playing with retorts and test tubes, or perhaps leaning back in a comfortable armchair in a darkened room and thinking.[2]

The implications of this pejorative use of "thinking" aside, the consequences of public suspicion are clearly acute. Political decisions are increasingly based on scientific information, discoveries, and theories. From SALT negotiations to abortion legislation, from nuclear energy to hairsprays, the decision-makers must rely either on whim--or on interpretations of scientific findings. Indeed, the cost of antagonism between the scientist and layman could be the life we live, or its ethical foundation. In a recent Science editorial discussion of the role of science in social responsibility a University of Washington professor decries the "weakening of an intellectual conscience that underpins critical discernment."[3]

Scientific language is part of the mystique. "Scientists have their mystery, ritual, and sign language,"[4] wrote Lord Ritchie-Calder in 1977, and the Science editorial continues, "The public is never excluded [from technical and scientific communication], but the content and style of such communication are so highly specialized as to discourage participation by any but the expert."[5] Gerald Holton ascribes "the chilling realization that our intellectuals, for the first time in history, are losing their hold of understanding upon the world"[6] to the rapid expansion of an

esoteric scientific vocabulary.

In the most visible response to communication problems between scientists and non-scientists, the American Association for the Advancement of Science has inaugurated a new journal for the educated layman, Science 80. Its editors are inviting the most literate and challenging voices in science to contribute to public understanding of scientific endeavor. Indeed, the scientific community has repeatedly expressed its concern with the dangers of gingerly and even antagonistic communication between scientists and humanists. But the hand outstretched, in both greeting and support, has been grasped but weakly by the literator. Communication is impeded by not only an arrogant sense that verbal artistry is evidenced chiefly in the humanities, but by a manifest uneasiness in coping with rhetorical style in scientific publication. An ironic situation has developed: while it is the scientific community that reaches out, it is the linguistic community that has at hand the most potent antidotes to the mystique of scientific language. The lonely scientific hunter in his darkened room is thinking in language no more esoteric than its specialized counterparts, and as open to analysis as dialects, for scientific language shares with other languages--historians' language, psychologists' language, Black English, phatic language--fundamental linguistic characteristics. Recognition of these shared features could be the means for establishing mutual confidence between the two cultures.

First, in language as symbolism, words represent things, processes, concepts, ideas. Symbolism in language is species--specific to man: although the chimps' recent demonstrations of sentence construction may modify this theory, there has been no major evidence to disprove the theory that sophisticated use of symbolic language is one of the major distinguishing differences between man and lower animals.

As symbols, words do not have a life of their own except to sound-intoxicated poets like Dylan Thomas or as metalanguage used to discuss other language. Because we tend to confuse language and reality itself, however, the apparently abstruse nature of scientific language seems to precipitate fear of science itself.

Still, a modicum of linguistic sophistication could alleviate the fear. A scientist -- or an English professor--discussing the relation of words to referents might discover and demonstrate the tractability of scientific language, for the verbalization of a scientific concept is quite likely to be less amorphous that that of a philosophical or literary concept. Surely, Bohr's formulation of complementarity can be no more challenging that "logical atomism" to explain, or to grasp.

2. Language is verbally symbolic. That the basic unit of language is the word is as fundamental in science as in other areas, although every academic discipline has its unique characteristics and problems. Economics, for example, demonstrates the use of many common words in a specialized sense, not merely more exact but carrying an entirely different specialized meaning: security, progressive, fix, short/long, bull/bear. Literature has an extensive metalanguage: trochee, noun, dangling participle, comma splice. Although scientific vocabulary is minutely detailed and demands great verbal exactness, the derivation of words is usually so clear that it can be used to show relationships among referents: The relationships among interphase, metaphase, and telophase in mitosis are easier to grasp through etymology then those among sad, melancholy, disheartened, and pensive.

3. In stressing the importance of the syntactical attribute of language, the linguists recognize that although the basic unit is the word, the meaning in language derives from syntax. As Joshua Whatmough expresses it, "Now it is not the minimal units, but their relations to one another..that performs the function necessary to the working of the code,"[7] for every word has a different meaning in every context. If one knew the complete vocabulary of science but no syntax or grammar, one would not know science; in fact, the mind would be hopelessly cluttered with a jumbled assortment of data.

But the syntax of scientific language is "our" syntax, and the connections it establishes actually facilitate the learning of its enormous vocabulary.

4. Language is systematic in vocabulary, syntax, and paragraph structure. Language is consistent and coherent: according to Whatmough, "like a family or society,

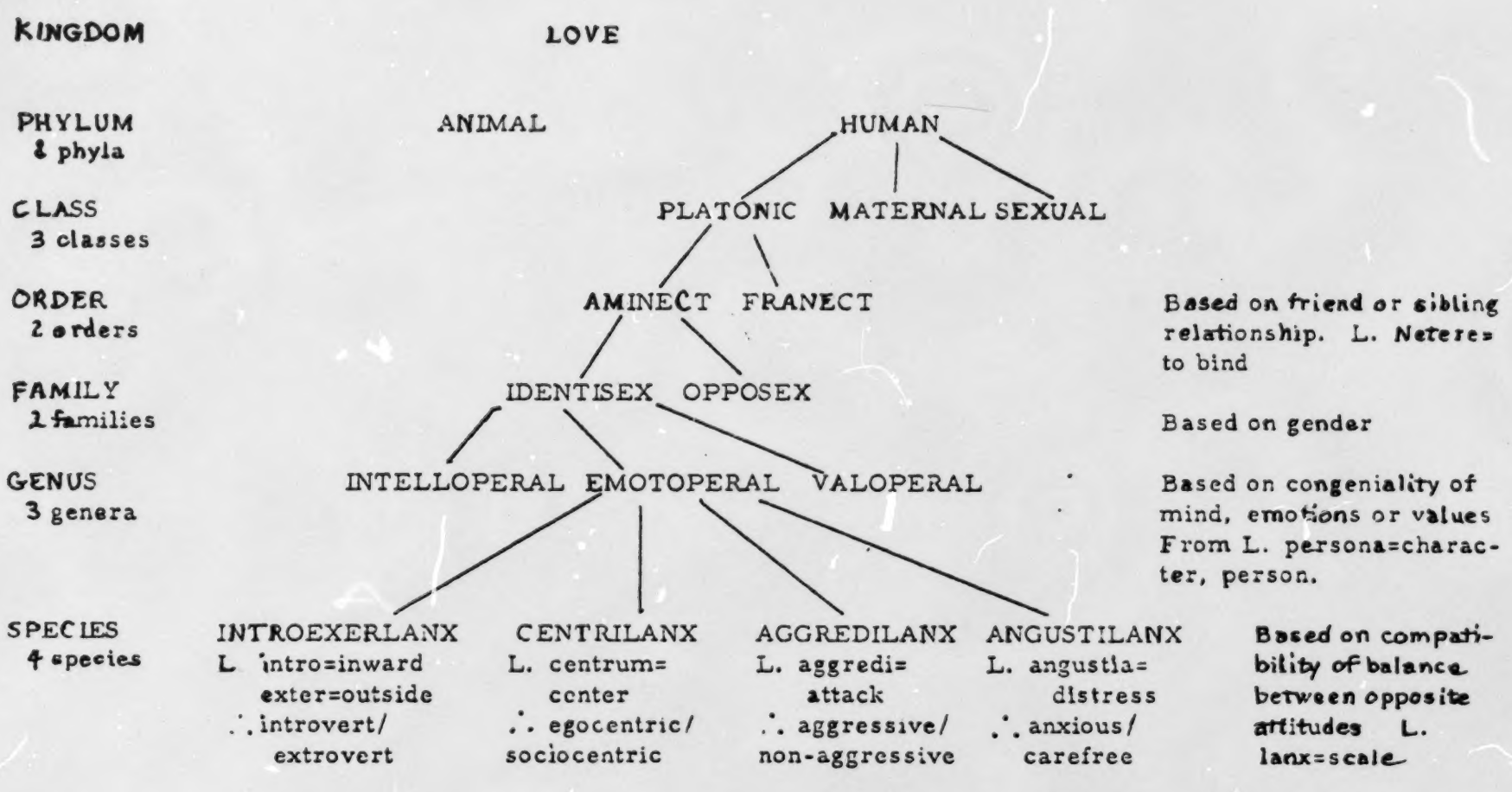
it is not a merely accidental collection of stray individuals."[8] Indeed, scientific language may be, with practice, easier to understand than sociological or philosophical language, because observations of other physical phenomena are more amenable to systematic arrangement than observations of humans, who always seem to be confounding generalizations about their behavior.

However, because of the social nature of language, its patterns are never simple and regular; and scientific language, being as socially motivated as any other, offers a range of patterns. The journal Science includes as many styles as Saturday Review, with research reports more predictably structured than biographical, philosophical, and argumentative writing.

5. Language is conventional, for meanings are arrived at by agreement. This implies quite properly that language is man-made, not ordained. Why is an anaerobic organism not an inaerobic organism? While it is a convention of English that an and in both mean not, it is a convention of scientific English that this particular word begins with an. Human beings, not nature, decided it. Human conventionality in science is also demonstrated by the practice of attaching to certain phenomena not only the traditional names of persons but tags from literature or imagination. Indeed, Murray Gell-Mann is quoted as discussing the origin of quark and gluon in playful terms. "The names are for fun. Why shouldn't you be able to enjoy yourself? ...I didn't know whether to spell it 'quark' or 'quork' until I saw it in print in James Joyce's Finnegan's Wake. I just thought it was a nice sound for this particle."[9]

The vocabulary of classification in science is large and detailed, but not because animal and plant life is by nature any more vast and detailed than other subjects. It is a convention, an agreement, for convenience in talking about life forms, since it is difficult to discuss something for which there is no name. Scientists have decided that infinitesimally different biological forms will be distinguished from each other by different names: the class mastigophora is classified into orders, families, genera, and species by the number and order of

flagellates, for example. But let us explore the possibilities if psychologists chose to construct a classification in the area of psychological relationships. An imaginary classification of species of LOVE is shown in the table. Consider the convenience of this identification: "Jane and Joan's relationship is of the species Aggredilanx" over "Jane and Joan are about equally aggressive; their close relationship seems to be based on reciprocity: Jane's aggressiveness is asserted only in situations where it is compatible with Joan's non-aggressive orientations, and she is not aggressive in the areas where Joan becomes aggressive."



Imaginary Classification of Four Species of Platonic Love

6. Language is perhaps 50% redundant, characterized by multiple verbal and syntactic cues to the meaning of a passage. Although it is generally agreed that scientists favor parsimony over redundancy, one need only open a textbook to find examples of multiple clues:

> Another taeniid, Echinococcus granulosus, is a dangerous parasite of man, causing the zoonosis "hydatid cyst." (See Fig. 28-3.) The cyst is the larval stage ordinarily found in sheep and goats which have acquired eggs of the adult tapeworm in grass contaminated by the feces of wolves or dogs. The natural cycle therefore involves canine animals as final hosts and ruminants as intermediates. Man acquires the eggs via contaminated food or intimate association with infected dogs.[10]

The third sentence is a simple repetition of the first two, and there are at least two clues that the danger is to humans, and at least three that dogs are significant in carrying the cyst. (This is not to speak of the repetition of information in Fig. 28-3.)

7. Language is connotative as well as denotative; in fact, some linguists believe that every word carries connotation. The denotative meaning of horse is limited to its reference as a variety of four-legged animals; horse may connote, however, strength, stolidity, equanimity, and grace. The "objective" word model may appeal to one scientist for its specificity, while it repels another because the model simplifies and distorts in the interest of enhancing visualization.

Textbooks often rely on connotation to heighten meaning:

> Of course, as Harrison Brown has pointed out, mankind may reproduce to the point of no escape from an agrarian bare-subsistence economy. In the latter case, Ascaria will thrive fantastically, celebrating the demise of civilization.[11]

"No escape," "fantastically," "celebrating," and "the demise of civilization" are all richly connotative, not clinically objective.

8. Language is replete with metaphor. The significance of metaphor in science derives from the basis on which "two unlike terms are compared by identification or by the substitution of one for the other."[12] Discoveries find their origin as well as their expression in analogy between scientific phenomena and other kinds of experience. Jacob Bronowski's eloquence was often directed toward the role of metaphor in science: "All science," he wrote in Science and Human Values, "is the

search for unity in hidden likenesses... The scientist looks for order in the appearances of nature by exploring such likenesses."[13] Among the examples that intrigue him is Kepler's use of metaphors in shaping his scientific inquiry:

> Kepler wanted to relate the speeds of the planets to musical intervals. He tried to fit the five regular solids into their orbits. None of these likenesses worked, and they have been forgotten; yet they have been and they remain the stepping stones of every creative mind. Kepler felt for his laws by way of metaphors, he searched mystically for likenesses with what he knew in every strange corner of nature. And when among these guesses he hit upon his laws, he did not think of their numbers as the balancing of a cosmic bank account, but as a revelation of the unity in all nature. To us, the analogies by which Kepler listened for the movement of the planets in the music of the spheres are farfetched. Yet are they more so than the wild leap by which Rutherford and Bohr in our own century found a model for the atom in, of all places, the planetary system?[14]

And George Gamow develops an extended metaphor to describe the origin of physics:

> It is very difficult to trace the origin of the science of physics, just as it is difficult to trace the origin of many great rivers. A few tiny springs bubbling from under the green foliage of tropical vegetation, or trickling out from beneath the moss-covered rocks in the barren northern country; a few small brooks and creeks running gaily down the mountain slopes and uniting to form rivulets which in turn unite to form streams big enough to deserve the name "river." The rivers grow broader and broader, being strengthened by numerous tributaries, and finally develop into mighty flows--be it the Mississippi or the Volga, the Nile or the Amazon--carrying their waters into the ocean.
>
> The springs which gave birth to the great river of physical science were scattered all over the surface of the earth inhabited by Homo sapiens, i.e., thinking man.[15]

9. Language is constantly changing and evolving. Here, indeed, scientists may claim that science adds to its vocabulary with greater grace than other fields where neologisms often constitute distasteful jargon. In any case,

> No set of symbols could possibly exhaust the events of nature, and thus new symbols are always being created, either to point to events in nature not heretofore considered or to new ways of organizing and developing meanings of already familiar matters.[16]

When lunar soil was first brought to earth, it was simply lunar soil. By now a number of other descriptive categories are being coined or borrowed from other geological phenomena to identify varieties of lunar soil as they are distinguished. "Mare soil" and "orange soil" for instance, join the language, but their general-

ity portends further classifying terminology.

In addition to adding neologisms, scientists change their linguistic style. Compare Pasteur's reports with the latest in Science, and it will be evident that the style of scientific literature has changed as much as the style of humanistic literature.

Language influences thinking. Certainly language, by the mere communication of reports through the professional journals, stimulates further thinking and research. But language affects thinking in a far more fundamental way. While it may seem natural to suppose that the function of language is to express thought, linguistic theory and empirical evidence indicate that thought also depends on language. Clarity, order, conceptualizing, and logic are mediated through language, and the uninhibited flow of verbal speculation may lead to important discoveries. "In language we have the free, accomplished use of symbolism, the record of articulate conceptual thinking; without language there seems to be no explicit thought whatever,"[17] writes Suzanne Langer. Ogden and Richards offer a more sweeping appraisal:

> Our whole outlook on life, our behavior, our character, are profoundly influenced by the use we are able to make of this, our chief means of contact with reality. A loose and insincere use of language leads us not only to intellectual confusion but to the shirking of vital issues or the acceptance of spurious formulae.[18]

Heisenberg tells it from the viewpoint of a scientist:

> The modern science of nature is arranging itself into an immense scheme of connection, which arises from the fact that men continue to ask questions, and that such questioning is the form in which they come to grips with the world about them.[19]

In examining the reality of plant species in a recent issue of Science, Donald A. Levin invokes John Locke as well as several modern scientists to suggest that taxonomy depends on language as much as nature: "Our concept of a species may result from the structure of our language and the structure of our brain. Language expresses a specifically human way of analyzing our experience of the external world."[20]

Scientific language, then, is human language before it is science. The mystique that we ascribe to it is of our own making, for physical, cognitive, and emotional phenomena are not so different that language cannot serve them all in similar fashion. Laymen who must make decisions affected by scientific research--and that is all of us--may take heart: we can deal with scientific language with the same benign skepticism and keen analysis that we apply to the language of other disciplines. Once students have been effectively disabused of the notion that scientific language is "different," we and they can approach rational use of the information transmitted by the scientists in textbook, newpaper--or scientific journals.

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